HISTORIC PROPERTY INVENTORY FORM

IDENTIFICATION SECTION

State of Washington, Department of Community Development
Office of Archaeology and Historic Preservation
111 21st Avenue Southwest, Post Office Box 48343
Olympia, Washington 98504-8343 (206)753-4011

Field Site No. 209-E **OAHP No.** **Date Recorded** 1 July 1997
Site Name Historic Critical Mass Laboratory
Common Plutonium Critical Mass Laboratory
Field Recorder Holly K. Chamberlain
Owner's Name U.S. Department of Energy, Richland Operations Office
Address P.O. Box 550
City/State/Zip Code Richland, WA 99352

LOCATION SECTION
Address 209-E Building, 200 East Area
City/Town/County/Zip Code Richland/Benton County/99352
Twp. 12 N **Range** 26 E **Section** 2 **I/4 Section** SW **1/4 1/4 Sec**
Tax No./Parcel No. **Acreage**
Quadrangle or map name Gable Butte, Wash., 7.5 minute series
UTM References Zone 11 **Easting** **Northing**
Plat/Block/Lot
Supplemental Map(s)

Status
- [x] Survey/Inventory
- [ ] National Register
- [ ] State Register
- [ ] Determined Eligible
- [ ] Determined Not Eligible
- [ ] Other (HABS, HAER, NHL)
- [ ] Local Designation

Photography
Photography Neg. No. (Roll No. & Frame No.) (See continuation sheet)
View of (See continuation sheet)
Date (See continuation sheet)

Photo at right, HCRL Roll No. 384, Frame No. 2.
View of north and east elevations.

Classification [ ] District [ ] Site [x] Building [ ] Structure [ ] Object
District Status [x] NR [ ] SR [ ] LR [ ] INV
Contributing [x] **Non-Contributing** [ ]
District/Thematic Nomination Name Hanford Site Manhattan Project and Cold War Era Historic District

Description Section
Materials & Features/Structural Types
Building Type Industrial
Plan L-shaped
Structural System Reinforced Concrete
No. of Stories One, with Two-story Reactor Hall

Roof Type
- [ ] Gable
- [x] Flat
- [ ] Monitor
- [ ] Gambrel
- [ ] Shed
- [ ] Hip
- [ ] Pyramidal
- [ ] Other (specify)

Cladding (Exterior Wall Surfaces)
- [ ] Log
- [ ] Horizontal Wood Siding
  - [ ] Rustic/Drop
  - [ ] Clapboard
- [ ] Wood Shingle
- [ ] Board and Batten
- [ ] Vertical Board
- [ ] Asbestos/Asphalt
- [ ] Brick
- [ ] Stone
- [ ] Stucco
- [ ] Terra Cotta
- [x] Concrete/Concrete Block
- [ ] Vinyl/Aluminum Siding
- [ ] Metal (specify)
- [ ] Other (specify)

Roof Material
- [ ] Wood Shingle
- [ ] Wood Shake
- [ ] Composition
- [ ] Slate
- [x] Tar/Built-up
- [ ] Tile
- [ ] Metal (specify)
- [ ] Other (specify)
- [ ] Not visible

Foundation
- [ ] Log
- [ ] Post & Pier
- [ ] Stone
- [ ] Brick
- [ ] Not visible
- Concrete
  - [ ] Block
  - [x] Poured
- [ ] Other (specify)

Integrity (Include detailed description in **Description of Physical Appearance)**

	Intact	Slight	Moderate	Extensive
Changes to plan	x			
Changes to windows	x			
Changes to original cladding	x			
Changes to interior unknown				
Other (specify)				

High Styles/Forms (Check one or more of the following)
- [ ] Greek Revival
- [ ] Gothic Revival
- [ ] Italianate
- [ ] Second Empire
- [ ] Romanesque Revival
- [ ] Stick Style
- [ ] Queen Anne
- [ ] Shingle Style
- [ ] Colonial Revival
- [ ] Beaux Arts/Neoclassical
- [ ] Chicago/Commercial Style
- [ ] American Foursquare
- [ ] Mission Revival
- [ ] Spanish Colonial Revival/Mediterranean
- [ ] Tudor Revival
- [ ] Craftsman/Arts & Crafts
- [ ] Bungalow
- [ ] Prairie Style
- [ ] Art Deco/Art Moderne
- [ ] Rustic Style
- [ ] International Style
- [ ] Northwest Style
- [ ] Commercial Vernacular
- [ ] Residential Vernacular (see below)
- [x] Other (specify) Industrial Vernacular

Vernacular House Types
- [ ] Gable Front
- [ ] Gable Front and Wing
- [ ] Side Gable
- [ ] Cross Gable
- [ ] Pyramidal/Hipped
- [ ] Other (specify)

NARRATIVE SECTION

Study Unit Themes (check one or more of the following)

[ ]	Agriculture	[ ]	Conservation	[ ]	Politics/Government/Law
[ ]	Architecture/Landscape Architecture	[ ]	Education	[ ]	Religion
[ ]	Arts	[ ]	Entertainment/Recreation	x	Science & Engineering
[ ]	Commerce	[ ]	Ethnic Heritage (specify)	[ ]	Social Movements/Organizations
[ ]	Communications	[ ]	Health/Medicine	[ ]	Transportation
[ ]	Community Planning/Development	[ ]	Manufacturing/Industry	x	Other (specify) Cold War Era
		[ ]	Military	x	**Study Unit Sub-Theme(s)** Chemical Separation; Research and Development

Statement of Significance

Date of Construction 1960 Architect/Engineer/Builder General Electric Company

x In the opinion of the surveyor, this property appears to meet the criteria of the National Register of Historic Places.

x In the opinion of the surveyor, this property is located in a potential historic district (National and/or local).

Although used to perform a variety of experiments on critical mass, the 209-E Building is distinguished from the few similar buildings in the United States by virtue of being the only such facility where criticality experiments were performed with plutonium solutions. Information obtained from experiments in the Critical Mass Laboratory was used to create specifications and procedures for the safe and economical shipping, handling, and processing of uranium and plutonium throughout the fuel cycle. The majority of the world's data on plutonium in solutions was derived from experiments carried out here. Operated by General Electric from the time of its construction in 1960 until 1965, when Pacific Northwest Laboratories took over its operation, the building was in use until 1988 when it was permanently shut down. During its main operational life, the laboratory typically housed 10-12 staff people, including scientists, technicians, and craftspeople, who carried out up to 50 nuclear physics experiments per year to study avoidance of accidentally creating a criticality in operating and storage facilities at the Hanford site and elsewhere.

(See continuation sheet)

Description of Physical Appearance

Located in the central 200 East Area, the Critical Mass Laboratory is an L-shaped, flat-roofed one-story concrete block building with a two-story reinforced concrete reactor hall. The building and its immediate environs (including a parking area) are surrounded by a perimeter fence, which has a gate at the northeast corner. An unstaffed badge house is situated to the west of the gate. The northernmost, or service wing, which measures 41 feet 4 inches by 80 feet, houses six offices, restrooms, control room from which experiments could be remotely conducted, lunch room/office, library, storage room, reproduction room, and a computer room. The southern, or reactor wing, measuring 45 feet by 113 feet, is comprised of an equipment room, change room, mixing room with glove boxes and a mixing hood, and a two-story reactor hall. Overall, the building comprises 6827 square feet.

(See continuation sheet)

Major Bibliographic References

Ballinger, M.Y. and Hall, R.B. 1991. *A History of Major Hanford Facilities and Processes Involving Radioactive Material* . PNL-6964 HEDR. Pacific Northwest National Laboratory, Richland, Washington.

Battelle Northwest. 1966. *Pacific Northwest Laboratory Monthly Activities Report for August 1966* . BNWL-320. Battelle Northwest, Richland, Washington.

Clayton, E. Duane. 1980. *Critical Mass Laboratory Experiments and Contributions* . PNL-SA-8898. Pacific Northwest Laboratory, Richland, Washington.

Clayton, E. Duane, former manager of the 209-E Critical Mass Laboratory. July, 1997. Interview. Richland, Washington.

(See continuation sheet)

HISTORIC PROPERTY INVENTORY FORM
209-E Critical Mass Laboratory
Continuation Sheet

Photography, continued
HCRL Roll No. 384, Frame 2

View of : North and East Elevations

Date: 1 July 1997

Photography Neg. No.: 7805681 – 2 CN

View of: East Elevation

Date: 1980

Photography Neg. No.: 32993-19

View of: Aerial from the South

Date: 11 July 1963

Photography Neg. No.: 32993-20

View of: Aerial from the North

Date: 11 July 1963

HISTORIC PROPERTY INVENTORY FORM
209-E Critical Mass Laboratory
Continuation Sheet

Building 209-E , East Elevation, 1980 (#7805681-2)

Statement of Significance, continued

The 209-E Building was the second critical mass facility built at the Hanford site. The previous one, the 120 Building (P-11 facility) in the 100-F Area, was comprised of a partly underground laboratory with a control room overhead in a pre-Manhattan Project farmhouse. The 209-E Building represented a significant improvement over the previous, somewhat more make-shift facility in that it was designed specifically to house critical mass experiments done under exacting safety conditions in a shielded structure. Design work for the building was begun in May,1958 by General Electric's Physics and Instruments Research and Development Department while construction started in April, 1959. The building was basically completed in March, 1960 but start-up was delayed until 1961 due to the late delivery of the main control panel and instrumentation system. Part of the delay was devoted to designing equipment for experiments on solid fuels and running safety tests on various pieces of equipment and systems prior to official start-up.

Many different types of nuclear criticality safety experiments were performed in the 209-E Building, including research on solutions, solids, fuel elements in lattice assemblies in water and in solutions of fissionable materials. Two hoods were available in the critical assembly room, one of which was reserved for solutions and one of which was reserved, starting in 1963, for solids. The original plans for the Critical Mass Laboratory called for an addition to be built later which would house experiments on solid materials. Budget constraints prevented the construction of that addition but staffers were still able to perform experiments on solids by using one of the two hoods within the reactor cell. Having two hoods was part of the original plan; the budget cutbacks resulted in reserving one hood for solid experiments and one for solutions experiments. Experiments done in the "solutions" hood were carried out by placing vessels holding the materials within it. The vessel was very often a 14-inch

Statement of Significance, continued

diameter metal sphere, used because of the geometric efficiency of the shape. Critical mass depends on geometry. A solution within a cylinder, for example, will become critical at various levels within the cylinder. Within a sphere, criticality will occur at all places at the same time. Solutions were also tested within tanks designed to be mounted into the solutions hood.

Although particularly known for experiments on solutions, Critical Mass Laboratory scientists also made significant strides in the area of testing solids. The “solids” hood enclosed a device known as the “remote split-table machine,” which was designed at the Hanford site. Cubes containing fuel materials moderated by polystyrene were stacked onto the two portions of the split-table. Neutron flux was measured by moving the two halves of the table together by remote control at the distance prescribed by parameters established by the experiment design. A sheet of plastic connecting the lower portions of the two table halves served to keep any cubes which fell from the table from hitting the floor and depositing contamination.

Experiments were also conducted outside the hoods. For example, barrels of radioactive solutions could be placed together within the reactor cell to test for safe storage of various quantities in various proximities and arrangements (subcritical neutron multiplication measurements). Also, fuel elements were placed in storage canisters in a variety of numbers and in different configurations to determine a critical mass safety margin. Experiments on New Production Reactor coextruded tube-in-tube configuration fuel assemblies fall into this category, as do those conducted for the United States Department of Energy on fuel assemblies for the Liquid Metal Fast Breeder Reactor Program at the Fast Flux Test Facility. The former were carried out essentially concurrently with the active life of the building. The latter began in the early 1970s and lasted for about 12 years.

HISTORIC PROPERTY INVENTORY FORM

Statement of Significance, continued

The critical assembly room also contained two rectangular neutron reflector tanks of 600 and 320 gallon capacity, only one of which was used at a time. During experiments, smaller tanks containing the trial nitric acid solutions of plutonium or uranium (which sometimes included neutron poisons such as boron, cadmium, and gadolinium) were placed within the larger tanks, with treated or raw water filling the intervening spaces. The moderator water served as both a neutron reflector and shield. In addition to obtaining the information generated by the specific experiment, laboratory staff were required to take samples from the reflector water to test for alpha activity which indicates rate of radioactive decay. Duplicate
samples were tested by the Hanford Environmental Health Foundation. The alpha activity had to be below a certain level in order for the tank to be drained.

In addition to solving everyday problems for clients at the Hanford site and holding classes on nuclear criticality safety for site workers, the Critical Mass Laboratory also served clients elsewhere in the United States and abroad. For example, U^{233} solutions were tested in 209-E in 1966 at the behest of the United States Navy to develop safe storage procedures for nuclear submarine fuel. The experiments consisted of arranging solution containers in different arrays, all separated by varying thicknesses of the transparent thermoplastic acrylic resin used as a moderator. Similarly, procedures were needed by staff at the Rocky Flats nuclear plant to ship and handle plutonium “buttons” in safe proximities. Critical Mass Laboratory scientists tested the buttons in precisely-machined and polished containers using the split-table machine.

Atomic energy interests in Japan were among the international clientele served. One series of experiments in the mid-1980s on mixed plutonium-uranium solutions in cylindrical and slab geometries done for the Power Reactor and Nuclear Fuel Development Corporation of Japan supplied information on what size the nuclear reprocessing equipment could be.

Statement of Significance, continued

Certain basic safety and security procedures were standard sitewide, but the Critical Mass Laboratory fell into a category of facilities requiring special treatment because nuclear materials were housed there. The facility had, for instance, its own separate badge house and double rows of perimeter fencing, which still exist, as well as a now-deactivated alarmed area between the fences. However, among Hanford site facilities holding special nuclear materials, this one was considered by security experts to be among those least likely to attract saboteurs. An external review done in 1985 in accordance with the general emphasis in the mid-1980s on assessing and improving security and safeguards in a cost-effective manner found that the Critical Mass Laboratory was relatively safe from sabotage because of the form and configuration of the special nuclear materials studied
there. An adversary would be unlikely to find 500 pound fuel assemblies and plutonium in solutions to be attractive targets for theft. A separate internal study done a year earlier positing a hypothetical criticality accident concluded that the containment capabilities built into the critical assembly room provided sufficient protection for both the public and laboratory staff, and that no upgrades were needed.

The thousands of critical mass measurement experiments performed in the 209-E Building resulted in a huge amount of data relating to the safe processing and storage of low-enriched uranium. Experiments on critical mass were needed to arrive at reliable and realistic estimates of how much critical material could be used or stored in what proximity without compromising nuclear safety. When presented with a real-life problem from somewhere at the Hanford site or elsewhere, scientists in 209-E made estimates on the appropriate amounts of material and distance and designed experiments on uranium and plutonium in solutions, plastic matrices, or in solid forms to test their hypotheses. The results of the experiments did not conclude exactly how many fuel elements, for example, stored in close proximity would result in a criticality, but rather defined a certain number as being safe.

Statement of Significance, continued

The nuclear criticality safety information gathered at 209-E is still being used today at the Hanford site toward, for example, safe storage of irradiated fuel from the N Reactor in the 105 KE and 105 KW basins. The only critical mass laboratory presently operating in the United States is at the Department of Energy facility at Los Alamos, New Mexico.

The Critical Mass Laboratory is significant under Criterion A, due to the experiments performed there making a substantial and lasting contribution to the safe processing, fabrication, shipment, and storage of nuclear materials at the Hanford site and elsewhere, and especially for the work with plutonium and uranium in solutions. Therefore, it is the conclusion of the U.S. Department of Energy that the 209-E Building is eligible for inclusion in the National Register of Historic Places as a contributing property within the Hanford Site Manhattan Project and Cold War Era Historic District.

Description of Physical Appearance, continued

The reactor, or critical assembly room, is constructed of 3 to 5 foot thick concrete walls, and a 2 foot thick concrete roof. The concrete is heavily reinforced with steel to withstand an explosion of up to three times the amount of force necessary to lift the roof. The interior of the reactor room has a reinforced fiberglass lining. The reactor room has an air supply system separate from the rest of the building, comprised of a fan with filters, heating coils, chilled water coils, and a spray chamber. In addition to this special ventilation system, the reactor room has additional fire protection systems. The door to the reactor cell was fitted with inflatable gaskets which totally sealed the room shut. Fail-safes were built in to ensure that the reactor cell would be inoperable unless the door was properly sealed, and the negative pressure system in operation.

Building 209-E, Looking North, 1963 (#32993-19)

The two hoods inside the cell sealed in a similar manner, and also had a lower pressure inside than outside so as to ensure that any spillage would remain inside the hood for safer clean-up. One hood housed the Solution Critical System for studying solutions, while the other was generally reserved for studies of solids using the Remote Split-Table Machine. Also within the cell was the Critical Experiment Assembly for Experiments on Interacting Arrays of Fuel Elements in Water (shipping cask type studies).

There were two neutron reflector tanks within the critical assembly room, both designed to have corrosion-resistant interiors. The larger, or 600 gallon tank, was made of steel with plastic viewing ports. The interior is coated with enamel paint. The smaller, or 320 gallon tank, was made of stainless steel with glass ports. Used as a receiving, handling, and experiment preparation facility, the mixing room had a containment hood in which plutonium solutions were prepared for use in the experiments. The solutions were then remotely pumped from vessels within the hood into the critical assembly room's slab tanks, in which the fissile solutions were prevented from reaching criticality by being separated by sheets of cadmium, water, and plastic. The mixing hood also contained a solution concentrator, in which plutonium nitrate or mixtures of plutonium and uranium were steam heated to concentrate them for storage and reuse. The control room held controls for remotely operating equipment within the cell to add solutions to a container within the cell.

There have been no major structural alterations made to the Critical Mass Laboratory but equipment, environmental, and security upgrades have resulted in some modifications. New equipment has been installed to permit various new types of experiments to take place or old ones be performed more safely or efficiently, such as the addition of a new solutions mixing tank in 1984. Between 1975 and 1986, considerable new equipment was put in place for making critical mass determinations about fuel pins for the Fast Flux Test Facility. These items included a fuel pin lattice test vessel (1975), a fuel pin processing tank (1980), and an annular tank for testing fuel pins in lattices (circa 1986).

Building 209-E, Looking South, 1963 (#32993-20)

Environmental concerns forced changes in the manner in which wastes were drained from the facility to further ensure that neither plutonium or uranium would be released. Prior to 1984, water used in the neutron reflector tanks as a neutron shield and reflector during criticality experiments was drained following the procedures through a floor drain into a 2-inch cast iron pipe, and through the laboratory wall into a 60-gallon capacity

Description of Physical Appearance, continued

Critically Safe Waste Hold Tank buried outside. From the holdup tank, the water was pumped to the 216-C-7 Crib. In 1984, the floor drains and drain pipe were sealed. Wastewater was then pumped directly to the 216-C-7 Crib via a new flexible hose drainage system. Drains in the mix room which had led to the 216-C-7 Crib were also sealed.

Security alterations in the mid-1980s arose out of sitewide concerns regarding improving the cost-effectiveness of systems already in place for preventing adversaries from obtaining special nuclear materials and installing new systems. Although a study concluded that the Critical Mass Laboratory was an unlikely target for saboteurs, relative to other facilities at the Hanford site, some suggested upgrades satisfied the screen of cost-effectiveness. These included the installation of television monitors atop the perimeter fence, lighting upgrades on the north perimeter, razor
ribbon, sensors and barrier upgrades on the steamline sensors, a fire door to the Critical Assembly Room, and alarm sensors in the badgehouse.

In 1988, operation of the Critical Mass Laboratory ceased. The 209-E Building is now occupied by Waste Mangement Hanford Services who provide environmental waste operations for the Hanford Site.

Major Bibliographic References, continued

DeMyer, J.J. and B.J. Merrill. 1985. *Assessment of Critical Mass Laboratory Safeguards and Security Upgrades*. PNL-D-405. Pacific Northwest Laboratory, Richland, Washington.

DeMyer, J.J. and B.J. Merrill. 1985. *209-E Upgrades*. PNL-D-394. Pacific Northwest Laboratory, Richland, Washington.

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General Electric Company. 1962. *Annual Report 1961*. HW-72000 DEL. Richland, Washington.

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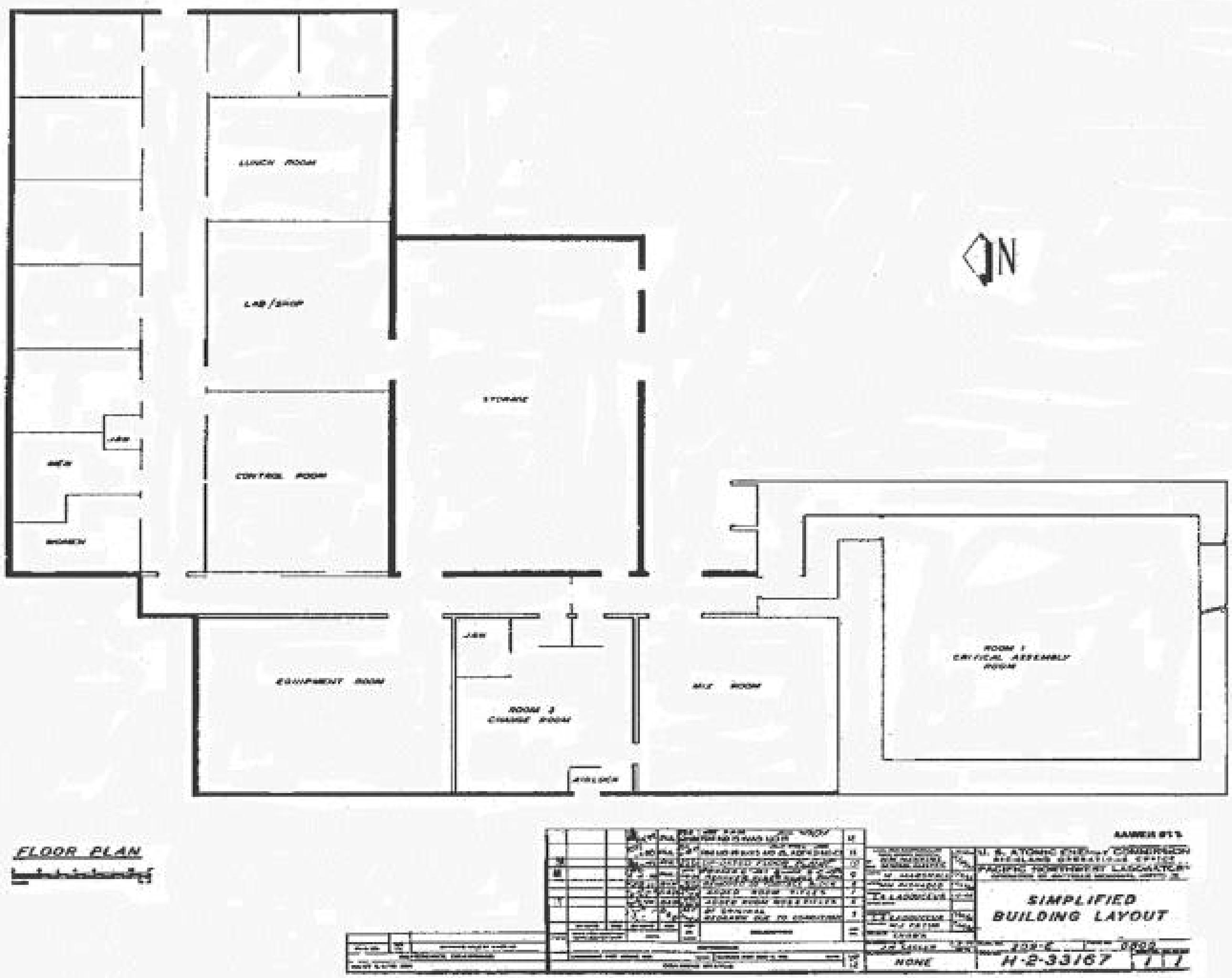
Gore, B.F., D.L. Strenge, and J. Mishima. 1984. *Consequence Analysis of a Hypothetical Contained Criticality Accident in the Hanford Critical Mass Laboratory.* PNL-5331. Pacific Northwest Laboratory, Richland, Washington.

Lloyd, R.C., and H. Funabashi. 1988. "Criticality experiments with mixed plutonium-uranium nitrate solution at plutonium fraction of 0.5, 0.4, and 0.2 in slab and cylindrical geometry." *Transactions of the American Nuclear Society*. Vol. 57, pp. 127-129.

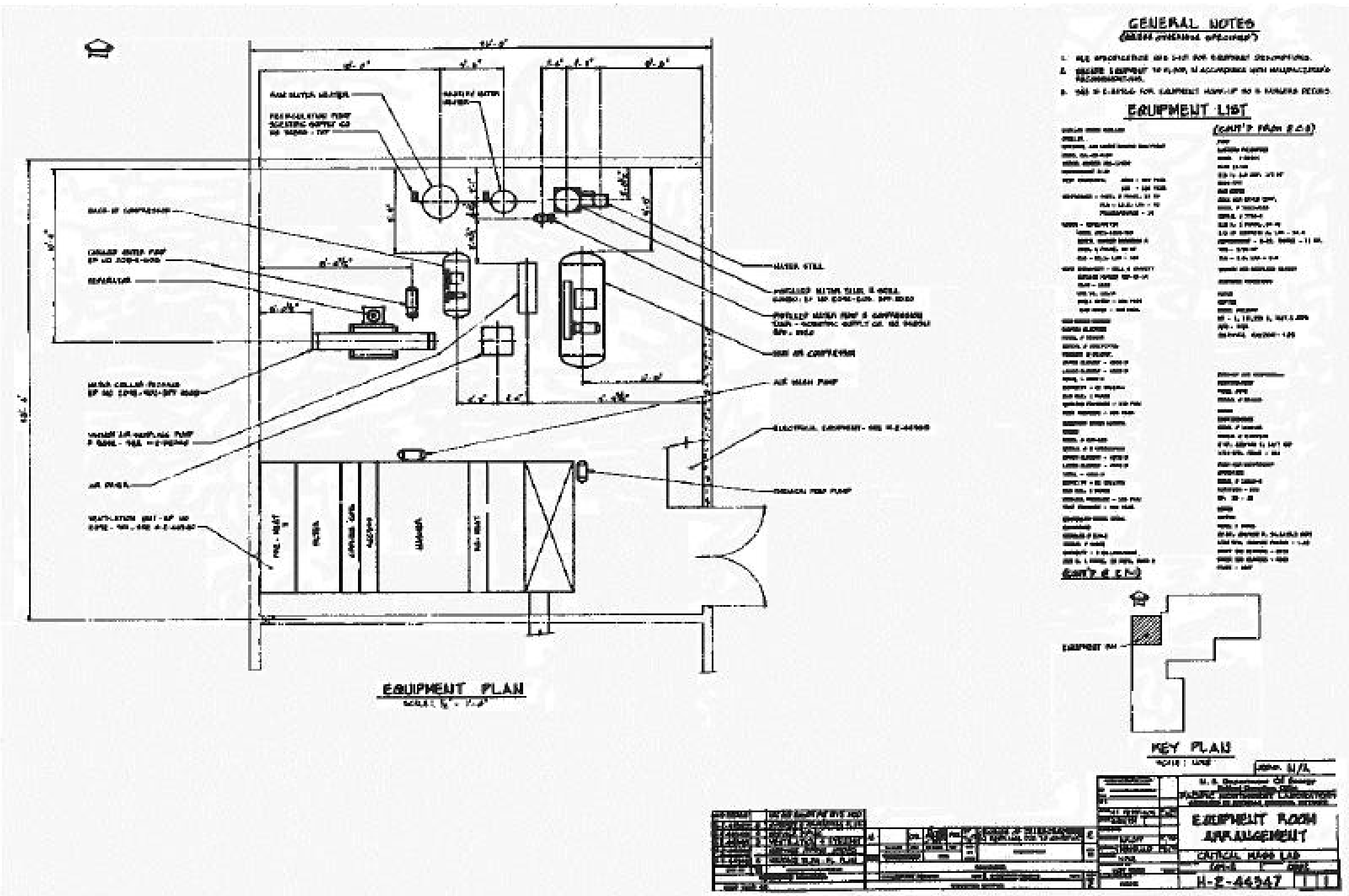
Neilsen, E.H. 1990. *209-E Laboratory Reflector Water Stream-Specific Report*. WHC-EP-0342 ADD 31. Westinghouse Hanford Company, Richland, Washington.

Major Bibliographic References, continued

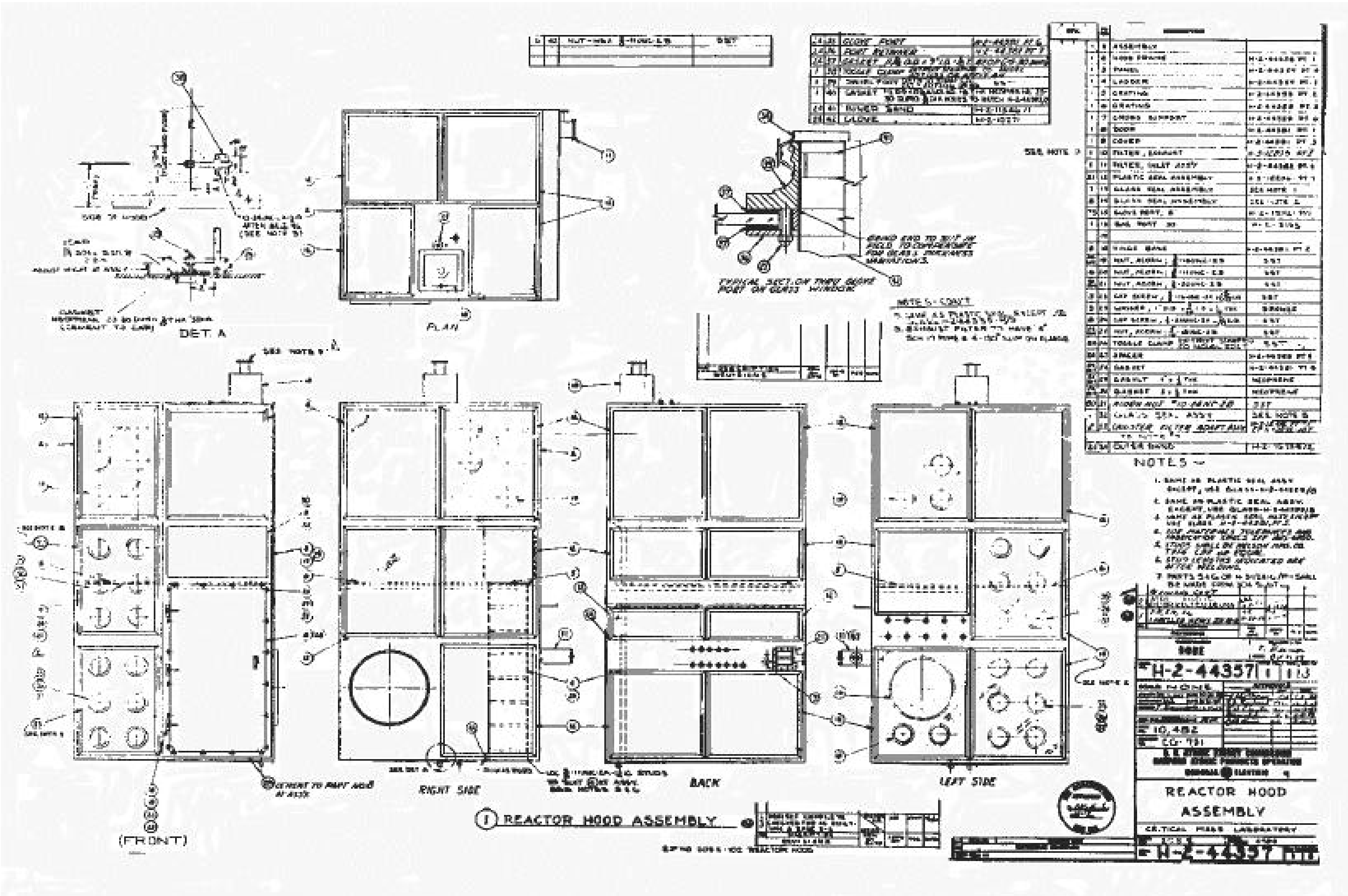
Toffler, Hans, Warren D. Wittekind, and Kevin N. Schwinkendorf. 1991. "Nuclear Criticality Safety of Low-Enriched Uranium Systems." *Transactions of the American Nuclear Society*. Vol. 64, pp. 257-259.


LUNCH ROOM
LAB/SHOP
STORAGE
JAN
MEN
CONTROL ROOM
WOMEN
N
JAN
EQUIPMENT ROOM
ROOM 3
CHANGE ROOM
AIRLOCK
MIX ROOM
ROOM 1
CRITICAL ASSEMBLY
ROOM
FLOOR PLAN
U. S. ATOMIC ENERGY COMMISSION
PACIFIC NORTHWEST LABORATORY
SIMPLIFIED
BUILDING LAYOUT
NONE
H-2-33167

Drawing H-2-33167, 209-E Simplified Building Layout, 1964



Drawing H-2-44347, Equipment Room, 209-E Critical Mass Laboratory, 1979



Drawing H-2-44357, Reactor Hood Assembly, 209-E Critical Mass Laboratory, 1959